

**CHEMICAL SENSING OF UNEXPLODED ORDNANCE
WITH THE
MOBILE UNDERWATER SURVEY SYSTEM (MUDSS)**

M. R. Darrach, A. Chutjian

Jet Propulsion Laboratory, California Institute of Technology
4800 Oak Grove Drive
Pasadena, CA 91109 USA

Abstract

The ability to sense explosives residues in the marine environment is a critical tool for identification and classification of underwater unexploded ordnance (UXO). Trace explosives signatures of TNT and DNT have been extracted from multiple sediment samples adjacent to unexploded undersea ordnance at Halifax Harbor, Canada. The ordnance was hurled into the harbor during a massive explosion fifty years earlier, in 1945 after World War II had ended. Laboratory sediment extractions were made using the solid-phase microextraction (SPME) method in seawater, and detection using the Reversal Electron Attachment Detection (READ) technique and, in the case of DNT, a commercial gas-chromatography/mass spectrometer (GC/MS). Results show that, after more than 50 years in the environment, ordnance which appeared to be physically intact gave good explosives signatures at the parts-per-billion level, whereas ordnance which had been cracked open during the explosion gave no signatures at the 10 parts-per-trillion sensitivity level. These measurements appear to provide the first reported data of explosives signatures from undersea UXOs.

I. Introduction

The detection of undersea UXOs is a matter of vital concern to several United States agencies, including the Department of Defence (US Navy, Army Corps of Engineers), and the Environmental Protection Agency. This issue has been highlighted as a result of the Base Realignment and Closure (BRAC) Act in which formerly-used defense sites (FUDS) will be returned to the civilian sector.

Central to the problem of undersea UXOs is their detection, by both physical means (*e.g.*, forward- and side-scanning sonars, magnetic-field gradiometers, electro-optical sensors) and chemical means (*e.g.*, seawater and/or sediment sampling and detection). A suite of these physical and chemical sensors has been incorporated into the so-called Mobile Undersea Debris Survey System (MUDSS) (1). The present study is aimed at testing the hypothesis that sediment sampling near a UXO, followed by chemical extraction and detection, can be a viable method of verifying an active target. To our knowledge, this is the first chemical evaluation under actual environmental conditions of sediment adjacent to old, live UXOs (2).

The site chosen for the sediment sampling was offshore of Rent Point in Halifax Harbor, Canada. On a historical note Halifax, Nova Scotia was a nexus for convoys destined for Europe during the Second World War. When the war ended, ships returning from Europe unloaded live ordnance of every type. A minor fire in 1945 caused detonation of the storage complex and for ten days explosions scattered large quantities of UXOs. After the explosions subsided a modest cleanup was pursued on land and the nearby shoreline was restricted to military personnel, leaving underwater UXOs undisturbed for 50 years. Hence all of the ordnance at Halifax could be expected to be live, with few if any inert rounds

Table 1. Summary of the SPME/READ Explosives Tests on Samples Collected at Halifax, Nova Scotia, Canada.

Target Number	Target Description	Sample Identification	Results
1	5" shell, poor condition broken open	A, B, C, D	no explosives detected
2	5" shell, very poor condition broken open	E, F, G, H	no explosives detected
3	5" shell, good condition intact	I, J W, X	no explosives detected (confirmed by GC/MS) TNT detected at low ppb concentrations
4	9" shell, semi-buried appeared intact	K, L M, N	DNT detected at high ppb concentrations no explosives detected
5	5" shells, very poor condition broken open	O, P, Q, R	no explosives detected (confirmed by GC/MS)
6	5" shell, semi-buried intact	T S, U, V	DNT detected at low ppb concentrations (confirmed by GC/MS) no explosives detected (confirmed by GC/MS)
7	background sediment sample	17, 20	no explosives detected

Literature Cited

1. The MUDSS is a JPL-USN Coastal Systems Station collaboration sponsored under the Department of Defense/Strategic Environmental Research and Development Program (SERDP).
2. See also, for example, Fauth, M. I. *Determination of the Fate of Fragmented or Unexploded Munitions and Munitions Ingredients in the Environment* □ a Literature Search, DTIC AD-B120489(L) C.1 (1988).
3. Grant, C. L.; Jenkins, T. F.; Meyers, K. F.; McCormick, E. F. *Env. Toxic. Chem.* **1995**, *14*, 1865.
4. Bruggemann, E. E. *HPLC Analysis of SEX, HMX, TATX, RDX and TNT in Wastewater*; Army Medical Bioengineering Research and Development Laboratory, Report USAMBRDL-TR-8206; Fort Detrick, MD, 1983.
5. Jenkins, T. F.; Miyares, P. H.; Meyers, K. F.; McCormick, E. F. *Anal. Chim. Acta* **1994**, *289*, 69.
6. Bernius, M. T.; Chutjian, A. *Anal. Chem.* **1990**, *62*, 1345.
7. Boumsellek, S.; Chutjian, A. *Anal. Chem.* **1992**, *64*, 2096.
8. Boumsellek, S.; Alajajian, S. H.; Chutjian, A. *J. Am. Soc. Mass Spectrom.* **1992**, *3*, 243.